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Influence of the supine or the prone position on the lung function of neonates with pneumonia

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Abstract: Objective To study the influence of the supine or the prone position on the lung function in the neonates with pneumonia in order to find a suitable position for neonates with pneumonia. **Methods** Respiratory rate, tidal volume, minute ventilation, airway resistance, dynamic pulmonary compliance and work of breathing in the supine or prone position were measured by American Biocore CP-100 Neonatal Pulmonary Apparatus in 30 neonates with pneumonia. **Results** Respiratory rate (44.3±9.2 bpm/min) and airway resistance [(153.1±50.4) cmH_2O/(L.sec)] in neonates with a prone position were significantly lower than those in the supine position [(48.0±10.6 bpm/min) and (211.9±63.1) cmH_2O/(L.sec), respectively] ($P<0.01$). Tidal volume (2.29±0.46 ml/kg), minute ventilation [(0.095±0.024) L/(min.kg)], dynamic pulmonary compliance [(0.621±0.214) ml/(cmH_2O.kg)] and work of breathing (8.9±3.5) gm/(cm.kg)] in the prone position were significantly higher than those in the supine position [(1.65±0.50 ml/kg), (0.075±0.022) L/(min.kg), (0.389±0.115) ml/(cmH_2O.kg) and (5.9±2.7) gm/(cm.kg), respectively] ($P<0.01$). **Conclusions** A prone position may increase the tidal volume, minute ventilation and dynamic pulmonary compliance and decrease respiratory rate and airway resistance. It suggests that a prone position is the suitable one for neonates with pneumonia. **[Chin J Contemp Pediatr, 2004, 6(3): 180-183]**

Key words: Pneumonia; Position; Lung function; Infant, newborn

仰俯卧位对新生儿肺炎患儿肺功能的影响

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[摘 要] 目的 探讨仰、俯卧位对足月新生儿肺炎患儿肺功能的影响,寻求足月新生儿肺炎患儿的合理体位。**方法** 应用美国 Bicore CP-100 新生儿肺功能仪分别检测 30 例新生儿肺炎患儿仰、俯卧位时的呼吸频率、潮气量、每分通气量、气道阻力、动态肺顺应性和呼吸功。**结果** 俯卧位呼吸频率和气道阻力明显低于仰卧位[(44.3±9.2 bpm/min) vs (48.0±10.6 bpm/min);(153.1±50.4) cmH_2O/(L.sec) vs (211.9±63.1) cmH_2O/(L.sec),差异有极显著性意义,$P<0.01$];俯卧位潮气量、每分通气量、动态肺顺应性和呼吸功明显高于仰卧位[(2.29±0.46 ml/kg) vs (1.65±0.50 ml/kg);(0.095±0.024) L/(min.kg) vs (0.075±0.022) L/(min.kg);(0.621±0.214) ml/(cmH_2O.kg) vs (0.389±0.115) ml/(cmH_2O.kg);(8.9±3.5) gm/(cm.kg) vs (5.9±2.7) gm/(cm.kg),差异有极显著性意义,$P<0.01$]。**结论** 俯卧位可改善新生儿肺炎患儿潮气量、每分通气量和动态肺顺应性,降低呼吸频率和气道阻力,提示俯卧位是改善新生儿肺炎患儿肺功能的适宜体位。

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[关 键 词] 肺炎;体位;肺功能;婴儿,新生

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Pneumonia is often found in neonates with high mortality. About 2 000 000 neonates worldwide died of pneumonia every year[1], which account for 5% – 35% of the autopsy amount of neonates[2]. The supine position has been used up to the present time, both domestically and abroad for neonates, but little research has been conducted about whether this position is rational for neonates with pneumonia. In this study a lot of pulmonary function indexes were compared on full-term neonates with pneumonia between two groups of supine and prone position respectively in order to evaluate the influence of body position on their lung functions and thus determine a suitable body position for them.

Subjects and methods

Subjects

This research was conducted in 30 neonates with pneumonia, among them 16 male and 14 female. Their average gestational age was 39.4 ± 1.0 weeks, and average date age was 15.3 ± 8.8 days. The average birth weight was 3 242 ± 437 g, and that at test was 3 453 ± 479 g. These neonates had no other diseases affecting the heart, the brain or the lung. The criterion for pneumonia included: 1) respiratory symptoms including cough, wheeze, cyanosis, foaming, choke by milk, dyspnea, etc. 2) howling or bubble tone from the lung. 3) intensified lung markings and dotted or patched infiltrates on chest radiograph even very few with emphysema[3].

No oxygen inhalation was needed for any of the neonates and their body temperature were within the normal range.

Pulmonary function examination

1) Indexes: respiratory rate, tidal volume, minute ventilation, airway resistance, dynamic pulmonary compliance and work of breathing. 2) Instruments used: neonatal pulmonary tachometer of Biocore (USA), Smartcath esophageal sac, CP-100 neonatal pulmonary function apparatus, and DICONIX 180si printer from Kodak.

Test methods

1) The initial body position, either supine or prone, for all testees were randomly decided. For each body position the child was put on the bed in the selected position with the head askew to one side and without a buttress under the neck. Neither theophylline drugs nor respiratory center Sedatives were taken within 3 days before the examination. The test was conducted half an hour after feeding and completed within the duration of 2 feeding times (3 hours). The interval of position alteration was be more than half an hour. 2) The Smartcath esophageal sac was put via the nostril to the lower 1/3 part of the esophagus (about the length from the nostril to the auricle of the same side plus that from the auricle to the xiphoid) and was linked to CP-100 neonatal pulmonary function apparatus to measure the thoracic pressure. The position of Smartcath esophageal sac was watched and adjusted, if needed, by the chart of esophageal pressure on the screen of CP-100 neonatal pulmonary function apparatus. 3) The nose and mouth of the testees were covered with the mask linked to the neonatal pulmonary tachometer in order to measure the velocity of air flow (the scale for this tachometer was 0.4 – 500 ml/sec). 4) The CP-100 neonatal pulmonary function apparatus was linked to the DICONIX 180si printer to record the thoracic pressure and the velocity of air flow for 10 continuous respiratory cycle. The data were processed by a PC and all indexes of pulmonary function were printed out. In order to be most accurate all indexes for each body position were measured three times and averaged unless the tidal volume was less than 0.5 ml/kg or more than 9 ml/kg.

Statistical analysis

All statistical data of the lung function were expressed as $\bar{x} \pm s$, and paired t tests were performed for each group of values from supine and prone position.

Results

The results were as follows: tidal volume, minute ventilation, dynamic pulmonary compliance and work of breathing in full-term neonates with pneumonia in the prone position were significantly higher than those of neonates in the supine position ($P < 0.01$). On the other hand the respiratory rate and airway resistance in neonates in the prone position

were significantly lower than those in the supine position ($P<0.01$). See Table 1.

Table 1 Comparison of lung mechanics between the neonates in the supine and the prone positions ($n=30, \bar{x} \pm s$)

	Respiratory rate (bpm)	Tidal volume (ml/kg)	Minute ventilation [L/(min. kg)]	Airway resistance [cmH2O/(L. sec)]	Dynamic pulmonary compliance [ml/(cmH2O. kg)]	Work of breathing [gm/(cm. kg)]
Prone position	44.3±9.2	2.29±0.5	0.095±0.024	153.1±50.4	0.621±0.214	8.9±3.5
Supine position	48.0±10.6	1.65±0.5	0.075±0.022	211.9±63.1	0.389±0.115	5.9±2.7
t value	3.032	3.717	6.547	5.009	6.954	4.385
P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Discussion

Lung functional examination for neonates is an important clinical diagnosis technique for the evaluation of pathological changes, severity and property of respiratory diseases, the assessment of drug efficacy, and the guidance of respiratory parameters adjustment[4]. Up to the present time most domestic as well as international researchers have focused on the influence of body position on the lung function of normal or mechanical ventilated neonates, while there have been no reports on its influence on neonates with pneumonia.

This report indicated that the respiratory rate in neonates with a prone position was significantly lower than that of the neonates with a supine position. A rational explanation is that a prone position can improve the degree of oxygen deficiency caused by insufficient ventilation of the alveolus in neonates with pneumonia[5]. Thus a little compensational increase of respiratory rate is enough for the body's oxygen requirement.

Hutchison et al[6] have reported that the tidal volume of health full-term neonates in a prone position had no difference with that in a supine position. But in this experiment the tidal volume in prone position in neonates with pneumonia was obviously higher than that in supine position. Maybe the tidal volume of neonates with pneumonia is lower than healthy full-term neonates due to obstructive ventilation disability. The body will summon up all available compensational mechanisms to meet its need for ventilation. The increase of tidal volume is partially attributed to the range of diaphragm movement. According to the Laplace equation (pressure = 2 × tension/ radius of the arc), the arc radius of the rear diaphragm (near the spine) is the shortest and so under the same tension from diaphragm contraction the pressure on the rear diaphragm is the greatest. Thus the movement of the rear diaphragm is the main reason for the change of lung volume[7]. The weight of abdominal content will oppress the rear diaphragm in a supine position interfering with the increase of tidal volume, but will not, or will only a little in prone position resulting in a distinct enhancement of tidal volume. Other factors contributing to the increase of tidal volume includes the decrease of airway resistance and the improvement of dynamic lung compliance. Since minute ventilation is the product of tidal volume and respiratory rate, the increase of tidal volume and decrease of respiratory rate in a prone position compared with a supine position could not ensure the difference of minute ventilation between them. In this study, however, the minute ventilation of neonates with pneumonia in a prone position was distinctly higher than that in a supine position. This suggests that the degree of tidal volume increase was greater than the decrease of respiratory rate. This was more favorable for the gain of partial pressure of oxygen and the loss of partial pressure of carbon oxide.

The decreased airway resistance in prone position in neonates with pneumonia helps to reduce the work of breathing for overcoming the airway resistance and dilate the trachea and bronchia for the ejection of respiratory tract secretion. In addition the decrease of wrong inhalation due to choking from milk and vomiting in prone position compared with supine position

was good for ameliorating the oxygen needed metabolism in tissue as well as inflammation in the lung. Finally the pulmonary compliance in neonates with pneumonia in a prone position is obviously higher than that in a supine position, which enhances the flexibility and volume of the lung bringing on a greater tidal volume and better ventilation under the same pressure.

The work of breathing is utilized to overcome the airway resistance and increase tidal volume and respiratory rate. Compared with that of normal full-term neonates (16.8 ± 9.6 g. cm/kg[8]), the work of breathing in neonates with pneumonia is markedly inferior. This study showed that the work of breathing of neonates with pneumonia in a prone position was higher than that in a supine position, which seemed disadvantageous for them. But the increased work of breathing was used to enhance tidal volume rather than overcome the airway resistance and elevate the respiratory rate because the airway resistance decreased while the tidal volume increased in a prone position. Thus the elevation of work of breathing appeared to improve the oxygenation of the blood.

In conclusion the prone position can increase the tidal volume, minute ventilation, dynamic pulmonary compliance and work of breathing and decrease respiratory rate, airway resistance in neonates with pneumonia. This suggests that a prone position can improve their lung function. As a prone position is one of the risk factors of sudden infant death syndrome[9], the neonates must be guarded seriously when in this position in case of the occurrence of sudden infant death syndrome.

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